Preventive Veterinary Medicine 103 (2012) 74–77

View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Elsevier - Publisher Connector

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed

Short communication

# Use of satellite images for geographical localization of livestock holdings in Brazil

Luiz Felipe Ramos Carvalho[a,b], Cristiano Barros de Melo[b,*,1], Concepta McManus[c,1], João Paulo Amaral Haddad[d,1]

[a] Ministry of Agriculture, Livestock and Food Supply – MAPA, Brasília, DF, Brazil
[b] UnB/FAV Campus Darcy Ribeiro Asa Norte, ICC Sul, 70.910-970 Brasília, DF, Brazil
[c] UFRGS e INCT_IGSPB, Porto Alegre, RS, Brazil
[d] UFMG, E.V, DMVP, Belo Horizonte, MG, Brazil

ARTICLE INFO

*Article history:*
Received 23 February 2011
Received in revised form 15 August 2011
Accepted 18 August 2011

*Keywords:*
Disease control
Geo-referencing
Google Earth®, Remote sensing

ABSTRACT

Google Earth® provides free access to satellite images and has been used in several areas that require cartographic information. The present study assessed the inconsistencies between geo-referencing of livestock premises by GPS and the acquisition of geographic coordinates by remote sensing (RS) images provided by Google Earth® in the Brazilian states of Bahia, Distrito Federal, Minas Gerais and Parana. The overall mean and standard deviation of the distances in the study were 30.98 ± 19.89 m. The mean distance differences between the two techniques were, for these states, 37.20 ± 19.75 m, 28.38 ± 17.38 m, 31.61 ± 15.72 m, 28.43 ± 24.30 m, respectively. Despite the fact that there is variation between the geo-referencing points using GPS and RS, geographical localization of health inspections should be useful as long as the errors between the results of the two methodologies are considered.

© 2011 Elsevier B.V. Open access under the Elsevier OA license.

## 1. Introduction

When investigating the influence of environmental and demographic characteristics on Foot and Mouth Disease (FMD) distribution, Málaga (1976) found that the temporal risk was directly related to animal movement. Geo-referencing has been recommended as a tool on which to base decisions in animal health programs, as well as to reduce costs and minimize the impact of a disease incursion (Morris et al., 2002) using the example of FMD. The motivation for this study was the development of a national database, including geo-referencing, which greatly enhances the power for decision-support tools that can be applied as soon as a serious infectious threat is detected. These tools include procedures to detect infected herds promptly, to protect uninfected farms against virus exposure and also to manage control policies.

Any object has its geographic localization established when it can be described in relation to other objects whose position is known or when its location is determined by a system of coordinates (D'alge, 2004). The Brazilian Ministry of Agriculture, Livestock and Food (MAPA) requires that all properties in Brazil with livestock have at least one point on the property geo-referenced (Brasil, 2009a).

Nevertheless, according to information from the coordination for FMD (CFA/MAPA) and questionnaire responses from the Animal Health Executor Agencies (OESA) of the Federative Units in Brazil, in October 2009 there were 2,701,141 livestock farms units in Brazil but only 647,304 (24%) had geo-referencing. This had been carried out mainly in high risk areas,

* Corresponding author. Tel.: +55 61 33072823; fax: +55 61 32736593.
*E-mail addresses:* cristianomelo@unb.br, cristus18@hotmail.com (C.B.de Melo).

[1] Fellow of CNPq productivity.

0167-5877© 2011 Elsevier B.V. Open access under the Elsevier OA license.
doi:10.1016/j.prevetmed.2011.08.006

such as borders between zones with different sanitary and health conditions or with other countries, as well as industrial poultry farms which were geo-referenced in the National Program for Poultry Health (PNSA).

Geo-referencing of livestock operations in Brazil is carried out for MAPA using "positioning by point" with farm buildings such as management corral, sheds or farmhouse of the property in sight, and the geographic point obtained using a GPS according to MAPA instructions (Brasil, 2009b). Brazil is the world's fifth largest country, both by area and population, with a total area of 8,514,877 $km^2$ (Skidmore, 2003). Of the 1.98 million km of roads, only 184,140 (9.3%) km are paved.

The difficulties faced in geo-referencing rural properties in Brazil can be seen in the case of Pará State, where the implementation of the program "Boi Guardião" of MAPA in partnership with the Agency of Agricultural Defense in Pará (ADEPARÁ) led to the geo-referencing of 14,731 farms in the municipalities of São Félix do Xingu, Ourilândia do Norte, Tucumã, Marabá and Eldorado dos Carajás in the south of the State. The cost of this was R$ 674,276 (£253.000) or on average R$ 45.77 (£17) per property. This could only be done outside the rainy season, during which it was impossible to reach properties by road or other terrestrial means except horses (Pará, 2010).

Orbital remote sensing (RS) consists of a system of data collection on the earth from sensors located on satellites (Mariano Júnior, 2006). When using images obtained by RS the users have to be conscious of the precision limits and applications of the coordinates obtained (Lima et al., 2009), because the image may hide geometric distortions which reduce spatial precision of the information. Excellent systems are often available in which the geometric quality of the information contained is unknown (Galo and Camargo, 1994). A cartographic base without quality can be an important source of failure with Geographical Information Systems (GIS) (Santos et al., 2008).

With technological improvements there has come an increase in number of users without specialization in cartography. The precision or tolerance necessary depends on the use of geo-referenced data, so it is important to know the quality of the cartographic product used. Some comparisons between the data collected by SR, GPS and conventional cartography concluded that an excellent precision is not necessary (Trentin, 2008; Silva and Nazareno, 2009) for the activities involved in animal sanitary defense. Therefore, the use of orbital images may be an option for geo-referencing farms for most of the actions carried out by animal sanitary defense in Brazil.

The software "Google Earth®" makes public access to satellite images possible (Simon and Trentin, 2009). This system joins together maps based on images with the capacity to navigate. The whole planet is covered by coloured medium resolution images derived from satellites with some areas covered by high resolution orbital images and others by aerial photographs (Ur, 2006). Google Earth® has already been used as a tool in disease control by Chang et al. (2009) who used the images for development of a Geographical Information System (GIS) for dengue surveillance in developing countries. Google Earth® now hosts high-resolution imagery that spans twenty percent of the Earth's landmass and more than a third of the human population. This contemporary high resolution archive represents an important, rapidly expanding, cost-free and largely unexploited resource for scientific inquiry (Potere, 2008). In this study, the aim was to evaluate the use of remote sensing as a tool for geo-referencing livestock properties to aid in health control in Brazilian farms.

## 2. Materials and methods

In the present study, 240 properties were randomly selected but 42 were discarded because of errors in the point register, in the name of the property, if the datum for geo-referencing used was not registered or if the coordinate was found in a place different from the farm being studied. This was possible using the coordinates obtained by GPS with Google Earth®.

Existing geographical coordinates were used from the register of 198 livestock properties compiled by the Local Veterinary Units (UVL) of OESA. These were randomly selected from the Federative Units of the Federal District (DF), Minas Gerais (MG), Paraná (PR) and Bahia (BA). The properties were geo-referenced by technicians from the UVL using point positioning with GPS equipment models "Garmin Etrex Vista ®" and "Garmin LX®" which have a factory error of 3–5 m.

At the time of GPS recording on the properties one of the following three points was observed: main door of the farmhouse, management corral or main gateway to the property when access to building and installations was not possible. These properties were located on images from Google Earth®, created between January 10 and May 1, 2010.

The geodesic topocentric reference of *datum* SAD69 (South American Datum 1969) was used for referencing the points collected by GPS on the farms when the properties were registered by OESA. These coordinates were transformed to the geodetic geocentric of *datum* SIRGAS2000 (Geocentric Reference System for the Americas) using the references of IBGE (Brazilian Census Bureau) resolution No. 1, of 25th February 2005 which are part of the official standardization system for transformation of geodetic references of the IBGE (TCGEO). The *datum* used by Google Earth® is WGS84 (World Geodetic System 1984). Because the values from this datum are compatible with SIRGAS2000 (BRASIL, 2005), no transformations were carried out. The distances between the geo-referenced points by GPS and images on the same properties were calculated. The comparison between the east (E) and north (N) points were compared using the UTM coordinates and those obtained by GPS and remote sensing and the vector obtained using Pythagoras Theory.

Statistical analysis of the discrepancies between the observed coordinates on land with GPS and those extracted from Google Earth® was carried out using Student's paired *t*-test in the program SAEG (Sistema de análises estatísticas e genéticas, 1997) after standardization using log transformation. Data were tested for normality using the Univariate procedure of SAS®.

**Table 1**
Means distances and standard deviations between coordinates observed on land using GPS and homologous positions from Google Earth®.

| FU | *n* | Vector east north (m) | | East (m) | | North (m) | |
|---|---|---|---|---|---|---|---|
| | | *X* | *S* | *X* | *S* | *X* | *S* |
| DF | 35 | 28.378 | 17.386 | −6.911 | 21.272 | 4.034 | 24.312 |
| MG | 71 | 31.608 | 15.721 | 2.943 | 25.686 | −4.375 | 23.636 |
| PR | 60 | 28.423 | 24.299 | 14.361 | 19.873 | −7.697 | 27.164 |
| BA | 32 | 37.198 | 19.744 | −4.385 | 28.495 | 0.443 | 30.69 |
| Total | 198 | 30.975 | 19.888 | 3.477 | 25.214 | −3.117 | 26.499 |

*n*, number; *X*, mean; *S*, standard deviation; m, meters; FU, Federative Unit; DF, Distrito Federal; MG, Minas Gerais; PR, Paraná; and BA, Bahia.

## 3. Results and discussion

The total number of livestock properties geo-referenced and the differences found between geo-references by point positioning using GPS and Google Earth® images by remote sensing in the Distrito Federal, Minas Gerais, Paraná and Bahia States are shown in Table 1. The discrepancies between the two methods was on average 30.98 ± 19.89 m. This is higher than those found by Lima et al. (2009) and Oliveira et al. (2009) who found differences between Google Earth® images and GPS of 20.90 ± 1.44 m and 7.49 ± 6.74 in urban areas of the municipalities of Itajubá-Minas Gerais State and São Leopoldo-Rio Grande do Sul State, respectively. Control points are easier to locate in urban areas. In the case of São Leopoldo municipality, differential GPS (DGPS) was used which reduces the predicted error in obtaining coordinates.

In the present study, no analysis of the pattern of cartographic accuracy developed by Galo and Camargo (1994) was carried out because the single point positioning technique of GPS is not used where cartographic accuracy is necessary, only where low precision navigation and surveys (Ishikawa, 2001). Comparing the two forms of positioning, there was a significant difference between the two points ($p < 0.01$) in both the North and East directions. According to Galo and Camargo (1994), the systematic differences can be caused by several factors, such as dynamic alterations of altitude and velocity of the satellite, as well as drag and variation in available time for sweeping during image capture of a scene (Ishikawa, 2001). There is also a considerable source of discrepancies in point positioning using GPS to obtain coordinates on land (Monico, 2000). Nevertheless, in the present case, an important source of discrepancies was a lack of standardization of the exact point of collection for geo-referencing the properties, using both GPS or RS. There was no register of when the geographical reference was the corral, farm gate or farmhouse door as defined by MAPA (Brasil, 2009a). Another problem was the difficulty in defining which building is the farmhouse or corral and what is its orientation. In the present study, the definition of the farmhouse could be presumed to be one building when collecting data by GPS and another when geo-referencing by satellite, resulting in a discrepancy of 52.62 m between the two measurements. Silveira et al. (2005) noted that the choice of points to geo-reference were important in the reduction of discrepancies in these cases.

According to Bueno et al. (2009), the use of geographic information without recognised cartographic quality may aid in certain activities that have to be carried out in the field. There are important examples on the usefulness of maps for animal health purposes which do not meet Brazilian cartographic rules such as the localization of farms by veterinarians. One of these was the eradication of African Swine Fever in Brazil, in which the maps used were made by the veterinarians involved in the eradication campaign from 1978 to 1984 (Moura et al., 2010). In the analysis of risk factors for brucellosis dissemination in São Paulo State, the properties were located using geo-referencing by point GPS (Dias, 2004). These studies achieved their goals, showing that the necessary precision of the geo-referencing of farms for animal health and cost of these actions was adequate.

Lozano-Fuentes et al. (2007) concluded that the combination of free mapping tools and free or low-cost GIS software has tremendous potential for use in Decision Support Systems to facilitate control of arthropod-borne diseases in resource-poor environments. Basic GIS data can, if lacking, rapidly be generated at minimal cost from satellite imagery and mapping tools available through Google Earth®.

Extrapolating the cost per property geo-referenced in Pará State (PARA, 2010) to obtain geographic coordinates of the 2,053,837 properties registered in the OESA and without existing geo-referencing in Brazil, the cost is estimated to be R$ 94,004,119 (£35 million). In some situations similar results may be obtained using RS, with lower costs, faster results and at any time of the year. If the real costs of GPS position collection were calculated, i.e. including salaries, vehicle maintenance, gasoline costs, these values would be considerably higher, possibly double or triple of those estimated. In this way, a remote system in which travel by animal health technicians could be minimized could save considerably in terms of costs and time, especially in a country such as Brazil with its continental size and lack of infrastructure to quickly reach isolated rural areas by road.

The main uses of geographical localization by the OESA are identification of best access routes, identification of neighbouring livestock properties, localization of sources of disease and establishing the movement of animals between regions. As the mean size of properties in Brazil is 63.75 ha (Brasil, 2007) and the smallest is 2 ha (da Silva, 2001), even with a discrepancy of 31.0 ± 19.9 m currently found here, it should be possible to correctly identify livestock properties as long as the collection point for geographic coordinates is not at the edge of the property. This is possible to identify on most of the available images especially due to the number of high resolution spatial images found for Brazil at present on Google Earth® (Trentin, 2008).

## 4. Conclusions

Remote sensing for locating livestock properties in Brazil using Google Earth® is a viable alternative in regions where the local technicians know of these properties and the main use about the information is routine animal health actions.

In geo-referencing using remote sensing for locating rural properties it is important that the coordinate is preferentially obtained in a well defined location away from the property limits.

## Conflict of interest

No conflict of interest was identified.


## Acknowledgements

Ministry of Agriculture, Livestock and Food Supply (MAPA/Brazil) and CNPq.


## References


Brasil. Ministério da Agricultura, Pecuária e Abastecimento, 2009. Controle da raiva dos herbívoros: manual técnico 2009. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Brasília, MAPA/ACS, 124 pp.

Brasil. Ministério da Agricultura, Pecuária e Abastecimento, 2009. Manual de Padronização sobre organização das informações sobre estrutura dos órgãos executores de defesa agropecuária, Emissão e controle da Guia de Trânsito Animal (GTA) e constituição e manutenção de cadastro de propriedades rurais, exploração pecuária e produtor rural. http://www.agricultura.gov.br/pls/portal/docs/PAGE/MAPA/SERVICOS/TRANSITO_QUARENTENA_DE_ANIMAIS/GTA_NOVO/MANUAL%20DE%20PADRONIZA%C7%C3O%205.0_0.PDF (accessed 03.03.10).

BRASIL. IBGE. Resolução do Presidente, 25 de fevereiro de 2005, 2005. Dá nova redação ao art. 21 e revoga o art. 22 do Decreto n° 89.817, de 20 de junho de 1984. que estabelece as Instruções Reguladoras das Normas Técnicas da Cartografia Nacional. Fundação Instituto Brasileiro de Geografia e Estatística, Brasília, DF.

Brasil. IBGE – Instituto Brasileiro de Geografia e Estatística, 2007. Censo Agropecuário 2006. Rio de Janeiro, Brazil.

Bueno, M.C.D., Pacheco, C.T., Pereira, C., Lima, L.A., Leite, L.A., Mattos, M.H.M., Moraes, R.S., 2009. Tecnologias geoespaciais e censos – a experiência de Cabo Verde. In: Proceedings of the 2nd Simpósio de Geotecnologias do Pantanal, Embrapa Informática Agropecuária/INPE, Campinas, Brazil, pp. 71–79.

Chang, A.Y., Parrales, M.E., Jimenez, J., Sobieszczyk, M.E., Hammer, S.M.J., Copenhaver, D.J., Kulkarni, R.P., 2009. Combining Google Earth and GIS zapping technologies in a dengue surveillance system for developing countries. International Journal of Health Geographics 8, http://www.ij-healthgeographics.com/content/8/1/49 (accessed 15.02.10).

D'alge, J.C.L., 2004. Cartografia para Geoprocessamento – Introdução à ciência da geoinformação. INPE, São José dos Campos, Brazil. http://www.dpi.inpe.br/gilberto/livro/introd/cap6-cartografia.pdf (accessed 12.02.10).

da Silva, J.G., 2001. Velhos e novos mitos do rural brasileiro. Estudos Avançados 15, 37–50.

Dias, R.A., 2004. Caracterização espacial da brucelose bovina no Estado de São Paulo, (PhD Thesis) Faculdade de Medicina Veterinária e Zootecnia da Universidade de São Paulo, São Paulo, Brazil, 111 pp.

Galo, M., Camargo, P.O., 1994. O uso do GPS no controle de qualidade de cartas. In: Proceedings of the 1st Congresso Brasileiro de Cadastro Técnico Multifinalitário, Florianópolis, Brazil, pp. 41–48.

Ishikawa, M.I., 2001. Estudo da Viabilidade da imagem IKONOS, produto Geo, para aplicações cartográficas urbanas, Presidente Prudente (M.Sc.), Faculdade de Ciências e Tecnologia, Universidade Estadual Paulista. Jaboticabal, Brazil, 82 pp.

Lima, S.L., Lima, J., Pons, P., N.A.D., 2009. Precisão aceitável? A utilização do Google Earth para obtenção de mapas viários urbanos para SIG. Infogeo 57, 35–36.

Lozano-Fuentes, S., Elizondo-Quiroga, D., Farfan-Ale, J.A., Fernandez-Salas, I., Beaty, B.J., Eisen, L., 2007. Use of Google Earth to facilitate GIS-based decision support systems for arthropod-borne diseases. Advances in Disease Surveillance 4, 91.

Málaga, H., 1976. Observaciones sobre el riesgo de ocorrência de fiebre aftosa. Boletim del Centro Panamericano de Fiebre Aftosa 23–24, 51–64.

Mariano Júnior, E., 2006. O uso do sensoriamento remoto orbital na pesquisa socioeconômica. Revista Científica Eletrônica de Agronomia, 10. Garça, Brazil. http://www.revista.inf.br/agro10/artigos/anov-edic10-art08.pdf (accessed 14.02.11).

Monico, J.F.G., 2000. Posicionamento pelo NAVSTAR-GPS: descrição, fundamentos e aplicações. UNESP Press, São Paulo, Brazil, 287 pp.

Morris, R.S., Sanson, R.L., Stern, M.W., 2002. Decision-support tools for foot and mouth disease control. Revue Scientifique et technique International Office of Epizootics 21, 557–567.

Moura, J.A., McManus, C., Bernal, F.E.M., Melo, C.B., 2010. An analysis of the 1978 African swine fever outbreak in Brazil and its eradication. Revue Scientifique et technique International Office of Epizootics 29, 549–563.

Oliveira, M.Z., Veronez, M.R., Turani, M., 2009. Imagens do *Google Earth* para fins de planejamento ambiental: uma análise de exatidão para o município de São Leopoldo/RS. In: Proceedings of the 14th Simpósio Brasileiro de Sensoriamento Remoto anais, INPE, Campinas, Brazil, pp. 1835–1842.

Potere, D., 2008. Horizontal positional accuracy of Google Earth's high-resolution imagery archive. Sensors 8, 7973–7981, doi:10.3390/s8127973.

Pará, 2010. Ofício ADEPARA no. 120/2010-DG, 24 March.

Silva, L.A., Nazareno, N.R.X., 2009. Análise do padrão de exatidão cartográfica da imagem do Google Earth tendo como área de estudo a imagem da cidade de Goiânia. In: Proceedings of the 14th Simpósio Brasileiro de Sensoriamento Remoto anais, INPE, Campinas, Brazil, pp. 1723–1730.

Santos, A.G., Segantine, P.C.L., Silva, I., 2008. Controle de qualidade de mapas digitais urbanos para uso em sistemas de informações geográficas. Minerva 5, 169–176.

Silveira, G.C., Sassaki, A.S., Neves, A.C.E., 2005. Escala máxima de uso do produto Ikonos-Geo: Estudo de caso para Araçoiaba da Serra. In: Proceedings of the 12th Simpósio Brasileiro de Sensoriamento Remoto, INPE, Goiânia, Brazil, pp. 2589–2596.

Simon, A.L.H., Trentin, G., 2009. Elaboração de cenários recentes de uso da terra utilizando imagens do Google Earth®. Revista electrónica de recursos en Internet sobre Geografía y Ciencias Sociales, 116. http://www.ub.edu/geocrit/aracne/aracne-116.htm (accessed 18.02.10).

Sistema de análises estatísticas e genéticas – SAEG, 1997. SAEG – Sistema de análises estatísticas e genéticas. User manual, version 7.1. Viçosa, Universidade Federal de Viçosa, Viçosa, Brazil, 150 pp.

Skidmore, T.E., 2003. In: Paz e Terra (Ed.), Uma História do Brasil, 4th ed., São Paulo, Brazil, 358 pp.

Trentin, G., 2008. A expansão urbano-industrial do município de Americana-SP: geotecnologias aplicadas à análise temporal e simulação de cenários. Rio Claro, 2008 (M.Sc.). Universidade Estadual Paulista, Instituto de Geociências e Ciências Exatas, Rio Claro, Brazil, 237 pp.

Ur, J., 2006. Google Earth and Archeology. SAA Archeological Record, pp. 35–38.